Inheritance of Venation Pattern in *Prunus ferganensis* × *persica* Hybrids

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Abstract

***Prunus ferganensis* (Kost. & Riab) Kov. & Kost, is closely related to cultivated peach, *P. persica* (L.) Batsch, but is distinguished by very long, unbranched leaf veins which turn and run parallel to the leaf margin at the edge of the leaf. Also, the pits have longitudinal grooves. Otherwise the tree and fruit of this species (or sub-species) resemble those of our familiar commercial peach. *P. ferganensis* is common in the dry Ferghana and Zeravshan Valleys in central Asia (now Tajikistan, Kyrgyzstan and Uzbekistan). In this region local cultivars of *P. ferganensis* are widely grown for fruit. Several old accessions of *P. ferganensis* such as Plant Introduction 102705 ('Khodjent Kostokos') are in the United States and a few additional accessions have been brought in as seed in recent years. Fruit quality is edible but not of commercial standard, particularly in terms of fruit firmness, quality and skin color. The species has been little studied in the US. Hybrids of *P. ferganensis* (primarily nectarine PI 102705) with commercial and experimental peaches have been produced, and segregating F_2 populations obtained. These populations were evaluated for fruit, seed and tree characters. The distinct leaf-vein character segregates in a ratio of 3 normal vein:1 long vein suggesting it is controlled by a single recessive gene. All of the long-veined progeny that fruited also had the grooves on the pit, in contrast to the normal seed of normal-veined seedlings. The preeminence of this species in its region of origin, where it is frequently cultivated, suggests the leaf morphology may be advantageous, perhaps in terms of water relations. If the long-vein leaf type were found to be associated with superior water usage or photosynthetic characteristics, it would be relatively easy to backcross it into commercial type fruit.**

INTRODUCTION

High crop productivity is critical to the peach industry. In most production areas water usage is an important factor in some (eastern U.S.) or all years (western U.S.). Although there is a range in water use efficiency among native *Prunus* species (Rieger and Duemmel, 1992), little is known about differences in water use and photosynthetic efficiency within peach and close relatives.

Prunus ferganensis (Kost. & Riab) Kov. & Kost is closely related to the cultivated peach [*P. persica* (L.) Batsch], but is distinguished by very long, unbranched leaf veins and longitudinal grooves on the pit. This species is native to the dry Ferghana and Zeravshan valleys in central Asia (Tajikistan, Kyrgyzstan and Uzbekistan) and Xinjiang province of arid northwestern China (Scorza and Okie, 1990). The region is characterized by scrub vegetation or grassland, and has an annual water balance (i.e. precipitation = potential evapotranspiration) of –600 to –950 mm (Korzun et al., 1977). Peach is native to more mesic, warmer regions of southeastern China, which have an annual water balance of about +125 mm. *P. ferganensis* is distinguished by having elongated, relatively unbranched secondary leaf veins that curve and run roughly parallel to the leaf margin (Komarov, 1941). In contrast to this "eucamptodromous" pattern, peach exhibits a "brachidodromous" venation pattern (Roth-Nebelsick et al., 2001), where the secondary leaf veins branch, and become progressively smaller and joined as they approach the leaf margin. Relatively large marginal veins would enhance water transport to the leaf margin (Roth et al., 1995), which experiences the highest water loss rates due to its thin boundary layer (Grace, 1977). Since *P. ferganensis* predominates in the driest extent of the habitat of peach and its close relatives, the long-veined leaf trait, or perhaps other associated traits, may be related to the enhanced drought tolerance observed for this species. No studies have been conducted on the leaf water relations, gas exchange properties, and drought responses of close peach relatives such as *P. ferganensis*, although there is a wide range of water relations characteristics and drought tolerance among more distantly related *Prunus* (Rieger and Duemmel, 1992).

Several old accessions of *P. ferganensis* are in the National Clonal Germplasm Repository at Davis, California and additional accessions have been brought in as seed in recent years. Older Plant Introductions include PI 102705 'Khodjent Kostokos', PI 113455 'Ferganensis #02446', PI 119842 'Ferganensis #0439, and PI 119844 'Krasvynos'. 'Krasvynos was used in the New Jersey breeding program and appears in the pedigree of 'Encore' and 'Summer Pearl' peaches (Werner and Okie, 1998). Otherwise the species has been little used by U.S. breeders. Fruit quality of the U.S. accessions is edible but not of commercial standard, particularly in terms of fruit firmness, quality and skin color. If the long-vein leaf type were found to be associated with superior water usage or photosynthetic characteristics, it would be relatively easy to backcross it into commercial type fruit.

MATERIALS AND METHODS

Accessions of *P. ferganensis* were hybridized with *P. persica* breeding selections carrying other traits of interest. PI102705 is a nectarine introduced as seed in 1933 under the name of 'Khodjent Kostokos' from Leningrad. The seed was reportedly collected in Turkestan. The freestone fruit has white, melting flesh, with little red blush, but cracks badly in our climate, as is typical of cultivars from drier regions. The tree is relatively late blooming (Werner and Okie, 1998). A second accession was obtained in 1988 as seed from the Beijing Botanical Garden and designated clone A3. It was a white, melting-flesh peach. Both accessions had the characteristic long leaf veins and associated longitudinal grooves on the pits. Parent BY90P3211 was a redleaf evergreen F_2 seedling of Rutgers Redleaf × PI442380, an evergreen peach from Mexico (Rodriguez-A. et al., 1994).

RESULTS AND DISCUSSION

In all the populations studied, long leaf veins were recovered in about 25% of the progeny, suggesting inheritance as a simple recessive gene. In each population, chi-square analysis showed the frequencies were not significantly different from the expected 25%. In all cases where fruit was observed, pits of trees with long veins also displayed the longitudinal grooves typical of this species. Either the gene is pleotropic, or the traits are closely linked.

In the population from the cross with BY90P3200, there appeared to be abnormal segregation, although the numbers are too small to estimate linkage. This group segregated for leaf color, vein type, fruit pubescence, and evergreen leaf. Out of 46 seedlings, there were 28 peach:8 nectarine (expected=3:1; 10 did not fruit). There were 13 homozygous redleaf:26 heterozygous redleaf (bronze):8 green (expect 1:2:1). There were 35 normal:11 evergreen (expect 3:1). However of the long-veined phenotypes, there was only 1 redleaf peach and 4 bronze leaf; there were 4 green leaf peaches and 1 green leaf nectarine. One would expect to recover long veins in the proportion 1 red:2 bronze:1 green. With only 1 green leaf peach and 2 green leaf nectarines with normal veins, the ratio for green leaf was 3 normal:5 long veins, different from the 3:1 expected. Since the long vein parent was green leaf, it appears these two traits may be linked. None of the other traits showed unusual segregation patterns.

The long leaf vein trait that characterizes *P. ferganensis* appears to be controlled by a single recessive gene, which confirms the report of D'Bov (1972) recently made available to us. The longitudinal grooves found on the seed segregate in association with the long leaf veins. The simple inheritance of these characteristics would seem to place *P. ferganensis* as only a sub-species of peach, rather than a distinct species. Hybrids of *P. ferganensis* with commercial peaches are readily made and segregating F_2 populations obtained. If the long-vein leaf trait were associated with morphological and/or physiological characteristics responsible for drought tolerance, simple inheritance would facilitate the incorporation of drought tolerance into commercially acceptable peach cultivars.

Therefore, we also undertook a study to examine comparative responses to drought in

P. ferganensis and *P. persica*, and in two of their interspecific hybrids: one possessing the long-vein trait, and the other without; and to investigate possible associations between the long-vein trait and morphological and physiological parameters associated with drought tolerance (Rieger et al., 2003). In the limited germplasm tested (from clone A3), only leaf size seemed to segregate with the long-vein trait of *P. ferganensis*, although three other parameters—evapotranspiration, specific leaf area, and photosynthetic end-product (sorbitol + sucrose) accumulation—were related to the genetic background of the genotypes studied. Physiologically, genotypes with *P. ferganensis* background behaved like typical xeric species by using water more opportunistically compared to *P. persica* when available. However, *P. ferganensis* and its hybrids, regardless of the long-vein trait, showed similar sensitivity of gas exchange to drought as *P. persica*, and all seem to respond by postponing dehydration through stomatal closure. At this point, the long-vein trait does not appear to present a suitable marker for breeding improved drought tolerance into peach, yet *P. ferganensis* shows evidence of other characteristics useful in peach breeding programs targeting drought tolerance.

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Tables

Table 1. Segregation of seedling populations for long veins. Expected values in parentheses based on 1:3 segregation ratio. Parent KK=PI 102705 Khodjent Kostokos.

Parentage		Long veins	Normal veins	Total plants	chi-square (P)
BY94N6583 =KK*Juneglo	self	12 (10.75)	31 (32.25)	43	0.07 (0.79)
BY94P6782 =KK*BY90P3252	op	7 (5)	13 (15)	20	0.60 (0.44)
BY94P6681 =KK*BY90P2490	op	4 (6.25)	21 (18.75)	25	0.65 (0.42)
BY93P4164 =KK*BY90P3211	op	8 (7.5)	22 (22.5)	30	0.00 (1.00)
BY93P4164 =KK*BY90P3211	self	10 (11.75)	37 (35.25)	47	0.18 (0.67)
BY89P3984 =*P. ferganensis* HBP op	self	21 (17.5)	49 (52.5)	70	0.69 (0.41)

Figures

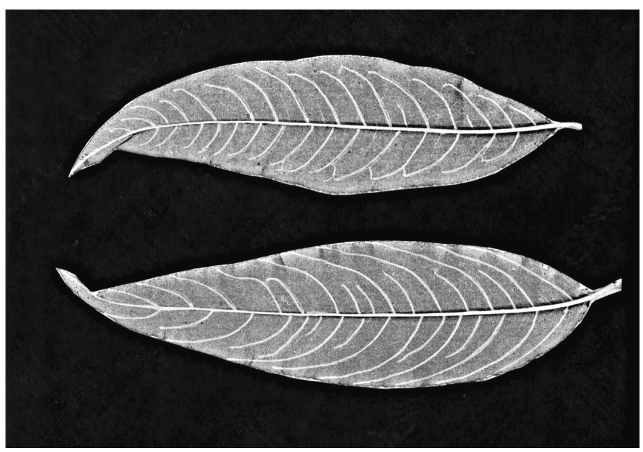

Fig. 1. Leaves of *Prunus persica* (top) and *P. ferganensis* (bottom), showing the elongated veins on the latter species.